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ABSTRACT

It was the purpose of this study to provide a tool for designing and executing future research on panel data in which relationships between pairs of variables are observed over time so that contingent conditions can be controlled. The 360 subjects were selected from the telephone directory and surveyed at random about their responses to the Watergate hearings. The findings were heuristic in that they demonstrated the potential usefulness of this approach in the analysis of panel data and provided the beginnings of a plausible conceptualization of a political socialization process. The most surprising aspect of these findings was that significant changes in variables relationships were often related to a lack of mass media use or to low attention to Watergate. The conceptual framework used in this study did not predict such results, which suggests that in some instances interpersonal communication, distrust of politicians, or Richard Nixon's image had more important effects for those who chose not to pay attention to the mass media. Future studies should consider the conceptualization of contingent variables for use in causal analyses of the type used in this study. (Author/RB)

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AN APPROACH TO THE ANALYSIS OF PANEL DATA: THE WATERGATE HEARINGS AND POLITICAL SOCIALIZATION

by

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An Approach to the Analysis of Panel Data*

Though communication theories frequently include references to changes in relationships between variables over-time, these relationships have often gone unstudied. Though panel data has been a potential source of information about changes in relationships between variables over-time, panels have been infrequently employed in communication research. In this paper, we have attempted to develop an approach for the analysis of relationships between pairs of variables over-time such that contingent conditions can be controlled for. We have applied Lazarsfeld's sixteenfold table approach and cross-lagged correlation to the analysis of a set of panel data. These techniques permit causal inferences to be made. We have then examined changes in the observed causal relationships which occur under differing contingent conditions.

Our analysis is purely exploratory. Its purpose is to provide a basis for designing and executing future research. Variables have been crudely measured and the techniques used to assess causal relationships impose assumptions which are not met by the data. We believe that our findings are heuristic in that they demonstrate the potential usefulness of this approach to the analysis of panel data and provide the beginnings of a plausible conceptualization of a political socialization process.

The Problem

From May until August 1973, the Senate hearings into the Watergate affair were given live television coverage by the three television

* The authors acknowledge the assistance provided by Sidney Kraus, Arthur Bochner and John Holm, CSU colleagues, who designed and supervised the data collection which provided the basis for this paper.

networks. The networks broadcast 319 hours of coverage which was viewed by an audience estimated to be substantially larger than usual for daytime television programming (Britannica, p. 659). While the hearings were being conducted, substantial changes in public opinion were registered by the public opinion polls. In particular, the popularity of President Nixon plummeted. The public apparently became increasingly convinced of the seriousness of the Watergate incident and of the possible involvement of President Nixon in its coverup. While the televised hearings coincided with these dramatic shifts in public opinion, it would be hazardous to consider them to be the sole or even the primary cause of these changes. Below, we have speculated on the impact of the hearings by linking them to a conceptualization of a process of political socialization.

Data Collection

A panel of 500 respondents was randomly chosen from the Greater Cleveland telephone book. Three hundred and sixty of these individuals were successfully contacted and surveyed by telephone during the week before the Senate hearings began on May 17, 1973. Subsequent surveys were conducted during the Memorial Day break and immediately after the testimony by John Dean ended on June 29th. In these subsequent waves, only 114 of the respondents contacted on the first wave could be recontacted. Data was collected on four sets of variables: a) mass communication use and exposure variables; b) an attention to the Watergate affair variable; c) an interpersonal communication variable; and d) political attitude and image variables. The mass communication variables were measured by asking respondents to name their primary sources

of information about the Watergate hearings. The attention to Watergate variable was measured by asking respondents to state whether they were giving no, a little, or a great deal of attention to the Watergate affair. Interpersonal communication was measured by asking respondents about how often they discussed Watergate matters with their family, friends or persons at work. Responses to three Likert-type items were summed to obtain a total score for interpersonal communication. Political attitudes and images were assessed using two different scales. One scale consisted of a ten item semantic differential measure of Nixon's image. The other measured distrust of politicians using five Likert-type scale items. For both measures, responses to items were summed to obtain total scale scores.

Data Analysis Techniques

In a previous paper (Davis and Lee, 1974), we discussed the application of three causal analysis techniques to this set of data. In this paper, we have focused on applying the sixteenfold table approach of Lazarsfeld and the cross-lagged correlation approach. We have extended our analysis beyond the preliminary findings reported in the earlier paper. The portion of this paper which discusses the causal analysis techniques used here is contained in the appendix.

In applying Lazarsfeld's sixteenfold table approach, we have not calculated the summary statistic described by Lazarsfeld. Instead, we have examined the cell frequencies in eight critical cells for causal evidence. Table II in the appendix indicates the critical cells and the causal interpretations which can be given to evidence contained in each.

These eight cells can be contrasted to produce estimates of four summary effects. The logic for this procedure has been explained in the appendix. These summary effects have been labeled α, β, θ, and ϕ using labels given to similar effects by Coleman (1964). These four effects can also be divided into two pairs α and β, θ and ϕ. These pairs should be complementary to one another. We have pointed out in our previous paper that when large amounts of incongruent or uncomplementary evidence is present, causal interpretations are made problematic.

The relevant evidence from our earlier analysis of the data has been reported in the four tables below in the columns labeled "Total Sample." The other columns in the tables show the various over-time relationships broken down by contingent conditions of media use and attention to Watergate. The relationships reported for the total sample suggest that the relationships between variables are changing markedly over-time. The relationships found from time one to time two are quite different from those found from time two to time three. When some inconsistent changes are ignored, the most interesting changes found are that the effects of interpersonal communication are clearly reversed with regard to distrust of politicians and to a lesser extent with regard to Nixon's image. Whereas, interpersonal communication was apparently responsible for creating distrust earlier, later it serves to dispel distrust. The evidence indicates that interpersonal communication initially contributed to a more positive image of Nixon but later produced a negative image. The effects of distrust also alter overtime. At first, distrust of politicians caused reduced interpersonal communication, later it was linked to increased interpersonal communication.

The effects of Nixon's image grew stronger. It became increasingly likely that persons having a positive image of Nixon would withdraw from interpersonal communication. In the case of both pairs of variables, variables are reciprocally related to one another such that neither can be assumed to be causing the other to change without being changed itself. Also, these reciprocal relationships are changing dramatically over-time.

It is possible to account for the observed changes in the relationships between variables in two ways. First, the changes may be due to an inadequate research design which permitted large amounts of fluctuating measurement error or a design which itself induced the changes observed. While we cannot discount this explanation completely, we have chosen to account for the observed changes using a conceptual framework. We have attempted a preliminary evaluation of the usefulness of this framework by controlling for a set of conceptually important contingent conditions. These are the conditions in which the changes we have observed should be most likely to occur if our conceptual framework is correct.

The approach which we have developed thus far can be summarized as follows. We used the sixteenfold table approach and cross-lagged correlation to assess the over-time relationships between theoretically interesting variables. Having observed what appear to be important reversals in these over-time relationships, we will attempt to construct a post hoc theoretical explanation for the reversals. This explanation will be used to select a set of contingent conditions. If these conditions are useful (i.e., serve to specify when the observed reversals are

most likely to occur) this will provide evidence in support of our post hoc explanation. Ideally, this explanation should eventually be tested using a new data set.

A Conceptual Framework

The fluctuations in the relationships between interpersonal communication and distrust of politicians and Nixon's image can be viewed as evidence of changes in a process of political socialization which underlies these variables. In this process, exposure to certain critical events or to communication about such events serves to disorient or to orient individuals toward political institutions. These events can be regarded as critical events because they play an important role in initiating changes or resolving ambiguities in the way that people think about or act toward political institutions. When such changes are initiated, they are reflected in changes in relationships between variables such as the ones we have considered above.

This conceptualization suggests that political socialization is a dynamic process which does not cease to produce significant changes after adolescence but continues to initiate changes during adulthood. Whenever critical events occur they initiate changes in the way that individuals orient themselves to political institutions. If this view is correct, research efforts should be directed toward: a) specifying such critical events; b) determining some variables which can serve as indicators of crucial changes in the political socialization process; and c) specification of the conditions when such critical events are most likely to be effective in initiating crucial changes in socialization, particularly conditions involving mass media. This view is com-

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plementary to and not in contradiction with the prevailing view that socialization primarily consists of reinforcement of existing beliefs or values. It does not deny that mass communication about many events may serve to reinforce. But communication about some events may be especially effective in introducing or resolving ambiguity about political institutions. If we focus our attention solely upon reinforcement, we may fail to note important effects of mass communication.

In this case, two critical events may be operating. Exposure of the cover-up of the Watergate incident was one critical event which may have disoriented many individuals concerning American political institutions. This disorientation was reflected in rapidly shifting opinions about government and public officials in national public opinion polls. The relationships which we observed from the first to the second measures of our panel may be the result of exposure of the cover-up. Some evidence would appear to support this argument. The data show that persons who were talking to others were coming to distrust politicians more and those with high distrust of politicians were tending to talk less with others. Persons with a positive image of Nixon were likely to stop talking to others. These findings suggest that exposure of the cover-up disoriented some members of the public affecting their views of Nixon and other public officials. Other individuals prevented disorientation only by cutting themselves off from interpersonal communication. It appears that in this situation the mass media have been provided with a powerful issue which enables the media to affect the political socialization process. The only finding which does not fit this interpretation is the data which indicates that Nixon's image is being improved by

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interpersonal communication prior to the hearings. This suggests that groups of Nixon supporters were able to sustain one another's image of Nixon despite contrary communications from the mass media. Even for these individuals, there may have been a growing distrust of politicians in general.

The second critical event was the televising of the Senate Watergate hearings. The effects of this event may be reflected in the relationships observed from time two to time three. The hearings may have served to do two things which are relevant to the relationships we studied. One, they may have demonstrated to the public that some politicians (i.e., the committee members) were honest, capable, and trustworthy. Second they may have convinced the public that President Nixon was at least partially responsible for Watergate. Thus, we find that interpersonal communication is leading people to be more trusting of politicians after the televised hearings. The negative relationship between distrust and interpersonal communication has disappeared. Interpersonal communication is resulting in a growing negative image of Nixon while those who have a positive image of Nixon are more likely to withdraw from interpersonal communication.

Specification of Contingent Conditions

We have argued that the changes observed from time two to time three were induced by the Watergate hearings. Because most persons received their information about the hearings from the mass media, it can be plausibly argued that those persons who sought out exposure to information about the hearings should be more likely to be affected by

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them. Thus, if the hearings are producing certain effects, these effects should be more pronounced among those who seek out particular mass media. Also, those persons who say they are giving a great deal of attention to Watergate should have been more likely to be affected. We chose four potentially useful contingent conditions from the data set. The measures of these variables at time two were used as contingent conditions. The media exposure variables were all responses to a single question. Respondents were asked to tell where they were getting their information about the hearings. A list of possible sources were read and they were asked to indicate whether or not a particular medium was used. These sources included: daytime, live television coverage; newscasts or night-time reviews; and newspaper reports. Respondents were also asked how much attention they were paying to Watergate. These contingent conditions are not ideal choices by any means. At best they serve only to illustrate the potential of the approach we have discussed. Below we have made some suggestions for designing more useful measures of contingent conditions.

Findings

Tables one and two report the data from the sixteenfold turnover tables which bear on the eight possible causal hypotheses and the four summary effects. Column one in the table reports the evidence for all 114 cases. The remaining pairs of columns report the evidence broken down by the various contingent conditions. In tables three and four, the cross-lagged zero-order and partial correlation coefficients are reported. Column one in each table reports these coefficients for all

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114 respondents and the remaining pairs of columns report the coefficients for the various contingent conditions.

(Tables One and Two About Here)

In general, these findings indicate that the differing contingent conditions do appear to be related to differences in changes in the relationships between variables. However, these differences are not always, or even very often, consistent with the conceptual framework we have proposed. In examining table one for evidence of changes in the relationships between interpersonal communication and distrust of politicians the following differences can be noted:

1) High interpersonal communication results in reduced distrust most often among persons who report newspapers or daytime television coverage as a source (Row 4).
2) Low interpersonal communication causes distrust to increase most among those who read newspapers, or who report low attention to Watergate (Row 6).
3) High distrust results in increased interpersonal communication most among those who don't watch daytime coverage, who read newspapers or who report low attention to Watergate (Row 10).
4) Low distrust results in increased interpersonal communication among those who read newspapers or who report low attention to Watergate (Row 14).

The last two findings are contradictory for the conditions in which newspapers are read or low attention is given to Watergate.

In examining table two for evidence of changes in the relationships between interpersonal communication and Nixon's image, the following findings can be noted:

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1) A positive image results in increased communication among those who read newspapers (Row 10). However, a positive image results in reduced communication among persons in this condition (Row 12). These findings are in direct conflict.

2) A negative image results in increased interpersonal communication most among those who watch no daytime television coverage (Row 14), who read newspapers, and who report low attention to Watergate.

3) A negative image of Nixon causes reduced interpersonal communication among those who report great attention to Watergate (Row 16).

(Tables Three and Four About Here)

Tables three and four report the cross-lagged zero-order and partial correlation coefficients. These correlations support some of the findings derived from the sixteenfold table analysis but some important contradictions exist. In the discussion below we have referred primarily to the cross-lagged partial correlations. The zero-order correlations are provided if readers wish to note differences between the two sets of correlations. In general, the two sets support the same conclusions. The cross-lagged partial correlations reported in table four support the following inferences:

1) High interpersonal communication is most likely to lead to reduced distrust of politicians or low interpersonal communication is most likely to lead to increased distrust of politicians under the following conditions: daytime television coverage of the hearings not watched, newspapers read, low attention paid to Watergate. This finding is consistent with

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the results of the sixteenfold table analysis except for the daytime television coverage condition. Where the findings are compatible, the sixteenfold table results offer some clues to sorting out the causal hypotheses which are confounded in the partial correlations. For example, the frequencies indicate that the negative relationship between interpersonal communication and distrust (partial correlation = -.45) in the low attention to Watergate condition is mainly due to low interpersonal communication leading to increased distrust. On the other hand, both confounded hypotheses are apparently true for the newspaper source condition.

2) High distrust of politicians is likely to lead to increased interpersonal communication or low distrust of politicians is likely to lead to reduced interpersonal communication in the condition where newspapers are not used as a source. This finding is directly contradicted by the sixteenfold table frequencies which indicate that when newspapers are used as a source, this contingent condition results in the effect described by the first causal hypotheses of this pair. Below, we have suggested an explanation for this apparent contradiction and a procedure for avoiding it in future research.

3) Low interpersonal communication results in an improved image of Nixon or high interpersonal communication results in a more negative image of Nixon in the condition where daytime coverage of the Senate hearings was watched. The sixteenfold table frequencies indicate that viewing of the hearings on daytime

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television was an important condition for the first of the causal hypotheses in this pair.

4) A more positive image of Nixon results in reduced interpersonal communication or a more negative image of Nixon results in increased interpersonal communication in the condition where daytime television coverage of the Senate hearings was not watched. The sixteenfold table frequencies indicate that not watching the television coverage of the hearings is a contingent condition for both of the hypotheses in this pair.

The two data analysis approaches agree that the use of newspapers as a source condition encourages those who have high interpersonal communication with others to reduce their distrust of politicians. It is interesting to speculate whether newspaper reports tended to highlight the trustworthy actions of Watergate panel members and that this focus encouraged those who discussed such reports to reduce their distrust. Or perhaps, those people who rely on newspapers as a source are more willing to be convinced that politicians are ethical than some of those who choose to use television as a source.

On the other hand, the comparison of the two sets of findings which we have presented above indicates that the newspaper as a source condition has produced some inconsistent findings. This is not surprising because persons in this condition constituted the largest group (83 persons out of 114). Persons in this condition may have been using newspapers in quite differing ways such that the condition produced apparently contradictory findings. If newspapers are being used differently, then both sets of findings may be true! Future research should

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not simply group respondents into a newspaper as a source condition but should categorize them according to their use of the newspaper. Thus, by separating individuals who expose themselves to newspapers on the basis of functionally opposing newspaper use patterns, it may be possible to produce useful findings.

The live television coverage of the hearings condition produced some consistent results although again one inconsistent finding is present. The sixteenfold table frequencies indicate that for five persons in this condition increased interpersonal communication resulted in reduced distrust of politicians while distrust was increased for only one person. However, the cross-lagged partial correlations indicate that increased interpersonal communication results in reduced distrust only for those persons who don't use daytime television coverage as a source. One way on interpreting this conflict is to consider that the cross-lagged correlations may be sensitive to a general trend in the data which the less precise sixteenfold table approach cannot gauge. On the other hand, the sixteenfold table approach has isolated five persons who directly contradict the trend suggested by the cross-lagged correlations. Are these persons atypical and the cross-lagged correlations correct or is the trend indicated by these correlations due to measurement error? This data set cannot answer this question. However, once again, both sets of conclusions may be correct. Future research should attempt to recategorize persons on the basis of functionally opposing uses of the coverage provided by the Senate hearings.

The two approaches also indicate that the televised hearings condition encouraged the following causal relationships: reduced interpersonal communication resulted in an improved image of Nixon and

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increased interpersonal communication resulted in a more negative image of Nixon. When the televised hearings were not used as a source, this condition encouraged the following causal relationships: a positive image of Nixon resulted in reduced interpersonal communication and a more negative image of Nixon resulted in increased interpersonal communication. These findings are somewhat consistent with the theoretical framework which we presented above.

The televised hearings may have been instrumental in encouraging the "resocialization" of at least some individuals. Those who were communicating with others were likely to come to think less of Richard Nixon. It is possible to speculate that the hearings may have "set the social agenda" for these persons. When they engaged in conversations with others, these conversations may have focused on the damaging evidence about Nixon's actions which the hearings revealed. As a result of these conversations persons may have been convinced that their prior positive image of Nixon was mistaken. On the other hand, the hearings also appear to have encouraged some persons to withdraw from a hostile "communication environment." Those persons who chose to withdraw are managing to maintain or even improve their image of Nixon even though they are watching the hearings. These persons may be using these broadcasts in a very different way from those who allowed the hearings to set their social agendas. These persons may be seeking evidence from the hearings which supports their views of Richard Nixon and apparently are successful in doing so. Perhaps, because the hearings failed to put the "smoking revolver in Nixon's hand" these individuals were encouraged to maintain their prior conceptions of him.

Interestingly, and in contradiction to the theoretical notions we presented above, the conditions in which media were absent also apparently encouraged certain causal relationships and when the media were used as sources these relationships were attenuated. The most striking of these findings is that when persons did not watch the hearings, a positive image of Nixon was more likely to result in reduced interpersonal communication while persons with a more negative image of Nixon were more likely to increase their interpersonal communication. Perhaps, those persons who did not watch the hearings became more defensive as the hearings provided everyone around them with information about Nixon that they did not want to confront. Thus, lacking the positive evidence about Nixon which they might have been able to glean from viewing the hearings, they became more likely to withdraw from communication with others. On the other hand, those with negative images of Nixon who could not watch the hearings (perhaps, because they worked during the day) were more likely to seek out others to find out about the hearings and confirm their suspicions of Nixon.

Summary and Conclusions

Our results have produced some interesting speculations and some suggestions to guide future research. In general, the use of both the sixteenfold table approach and cross-lagged correlation appears to be warranted for the analysis of exploratory panel data. Both methods should produce complementary results. When such results are found greater confidence can be placed in them. The sixteenfold table approach has the advantage of actually locating individuals who have

undergone theoretically interesting changes under specified conditions. However, the technique is insensitive (relying on dichotemized variables) and cannot take full advantage of the information contained in some data sets. Thus, when a researcher has confidence in his measures of variables; has measured these variables precisely using metric scales; and is relatively certain of the linearity and the causal direction of the relationships between variables; he should choose to rely on cross-lagged correlation alone.[1] This technique makes the most efficient use of the information contained in such a data set. The technique has the advantage of being able to accurately delineate trends in the data (if variables have been precisely measured). It may be important to isolate such trends rather than locate a few individuals who have undergone dramatic, theoretically significant changes.

The simultaneous application of the two approaches forced reconceptualization of the mass media source conditions. The individuals isolated by the sixteenfold table approach were in several instances in apparent contradiction with the trends found by cross-lagged correlation. We argued that this data set cannot resolve these contradictions. Both sets of findings may be correct if the media conditions were actually producing conflicting effects because people were using the media in functionally opposing ways for this event. We suggested that in future research, such opposing patterns of media use should be isolated and studied. If our speculation is correct, it should be possible to explain apparent conflicts in these findings. This should be a major objective of future research.

The theoretical framework presented above has been partially supported by the data analysis. It should be refined and developed in future research. The specification of important media use conditons which encourage certain causal relationships aid in the development of this theory. Ideally, a conceptual framework can be developed which combines the strong points of both the agenda setting conceptualizations and the uses and gratifications conceptualizations which are being used increasingly by mass communication researchers. It may be possible to link all of this research together under a common theoretical framework like the one which we introduced above.

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Table One

Sixteenfold Table Data for the Hypotheses Involving Interpersonal Communication and Distrust of Politicians

Row	Times	Hypotheses[1]	Total Sample[2] (N=114)	Contingent Conditions: Daytime TV (N=66)	No Daytime TV (N=48)	Newscasts (N=50)	No Newscasts (N=64)	Newspapers (N=83)	No Newspapers (N=31)	Great Attention to Watergate (N=60)	Low Attention to Watergate (N=54)
1	1 to 2	H_1: $+X \rightarrow Y\uparrow$	8								
2	2 to 3	H_1: $+X \rightarrow Y\uparrow$	0	0	0	0	0	0	0	0	0
3	1 to 2	H_2: $+X \rightarrow Y\downarrow$	3								
4	2 to 3	H_2: $+X \rightarrow Y\downarrow$	6	5	1	3	3	6	0	4	2
5	1 to 2	H_3: $-X \rightarrow Y\uparrow$	4								
6	2 to 3	H_3: $-X \rightarrow Y\uparrow$	7	4	3	3	4	6	1	1	6
7	1 to 2	H_4: $-X \rightarrow Y\downarrow$	6								
8	2 to 3	H_4: $-X \rightarrow Y\downarrow$	3	2	1	0	3	1	2	1	2
9	1 to 2	H_5: $+Y \rightarrow X\uparrow$	4								
10	2 to 3	H_5: $+Y \rightarrow X\uparrow$	5	1	4	3	2	5	0	1	4
11	1 to 2	H_6: $+Y \rightarrow X\downarrow$	8								
12	2 to 3	H_6: $+Y \rightarrow X\downarrow$	6	3	3	2	4	4	2	4	2
13	1 to 2	H_7: $-Y \rightarrow X\uparrow$	6								
14	2 to 3	H_7: $-Y \rightarrow X\uparrow$	5	2	3	3	2	4	1	1	4
15	1 to 2	H_8: $-Y \rightarrow X\downarrow$	3								
16	2 to 3	H_8: $-Y \rightarrow X\downarrow$	10	5	5	5	5	5	5	5	5
17	1 to 2	$\alpha = +X \rightarrow Y\uparrow$	4								
18	2 to 3	$\alpha = +X \rightarrow Y\uparrow$	-7	-4	-3	-3	-4	-6	-1	-1	-6
19	1 to 2	$\beta = -X \rightarrow Y\downarrow$	3								
20	2 to 3	$\beta = -X \rightarrow Y\downarrow$	-3	-3	0	-3	0	-5	2	-3	0
21	1 to 2	$\theta = +Y \rightarrow X\uparrow$	-2								
22	2 to 3	$\theta = +Y \rightarrow X\uparrow$	0	-1	1	0	0	1	-1	0	0
23	1 to 2	$\phi = -Y \rightarrow X\downarrow$	-5								
24	2 to 3	$\phi = -Y \rightarrow X\downarrow$	4	2	2	3	1	1	3	1	3

[1] X variable is Interpersonal Communication, Y variable is Distrust of Politicians.
[2] N is the number of persons in each contingent condition.

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Table Two

Sixteenfold Table Data for the Hypotheses Involving Interpersonal Communication and Nixon's Image

Row	Times	Hypotheses[1]	Total Sample[2] (N=114)	Contingent Conditions: Daytime TV (N=66)	No Daytime TV (N=48)	Newscasts (N=50)	No Newscasts (N=64)	Newspapers (N=83)	No Newspapers (N=31)	Great Attention to Watergate (N=60)	Low Attention to Watergate (N=54)
1	1 to 2	H_1: $+X \rightarrow Y\uparrow$	4								
2	2 to 3	H_1: $+X \rightarrow Y\uparrow$	1	0	1	0	1	0	1	0	1
3	1 to 2	H_2: $+X \rightarrow Y\downarrow$	2								
4	2 to 3	H_2: $+X \rightarrow Y\downarrow$	1	1	0	1	0	1	0	1	0
5	1 to 2	H_3: $-X \rightarrow Y\uparrow$	0								
6	2 to 3	H_3: $-X \rightarrow Y\uparrow$	2	2	0	0	2	1	1	0	2
7	1 to 2	H_4: $-X \rightarrow Y\downarrow$	2								
8	2 to 3	H_4: $-X \rightarrow Y\downarrow$	1	1	0	0	1	1	0	0	1
9	1 to 2	H_5: $+Y \rightarrow X\uparrow$	5								
10	2 to 3	H_5: $+Y \rightarrow X\uparrow$	4	2	2	2	2	4	0	1	.3
11	1 to 2	H_6: $+Y \rightarrow X\downarrow$	4								
12	2 to 3	H_6: $+Y \rightarrow X\downarrow$	12	5	7	7	5	8	4	5	7
13	1 to 2	H_7: $-Y \rightarrow X\uparrow$	7								
14	2 to 3	H_7: $-Y \rightarrow X\uparrow$	5	1	4	3	2	4	1	1	4
15	1 to 2	H_8: $-Y \rightarrow X\downarrow$	9								
16	2 to 3	H_8: $-Y \rightarrow X\downarrow$	6	4	2	2	4	2	4	5	1
17	1 to 2	$\alpha = +X \rightarrow Y\uparrow$	4								
18	2 to 3	$\alpha = +X \rightarrow Y\uparrow$	-1	-2	1	0	-1	-1	0	0	-1
19	1 to 2	$\beta = -X \rightarrow Y\downarrow$	0								
20	2 to 3	$\beta = -X \rightarrow Y\downarrow$	0	0	0	-1	1	0	0	-1	1
21	1 to 2	$\theta = +Y \rightarrow X\uparrow$	-2								
22	2 to 3	$\theta = +Y \rightarrow X\uparrow$	-1	1	-2	-1	0	0	-1	0	-1
23	1 to 2	$\phi = -Y \rightarrow X\downarrow$	5								
24	2 to 3	$\phi = -Y \rightarrow X\downarrow$	-6	-1	-5	-5	-1	-6	0	0	-6

[1] X variable is Interpersonal Communication, Y variable is Nixon's Image

[2] N is the number of persons in each contingent condition.

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Table Three

Cross-lagged Zero-order Correlation Coefficients for the Relationships between Interpersonal Communication and Distrust of Politicians

Times	Hypotheses	Total Sample (N=114)	Daytime TV (N=66)	No Daytime TV (N=48)	Newscasts (N=50)	No Newscasts (N=64)	News-Papers (N=83)	No News-Papers (N=31)	Great Attention to Watergate (N=60)	Low Attention to Watergate (N=54)
1 to 2	Distrust → I. Comm.	-.17								
2 to 3	Distrust → I. Comm.	.02	.07	-.03	-.01	.04	-.04	.28	.11	.03
1 to 2	I. Comm. → Distrust	.12								
2 to 3	I. Comm. → Distrust	-.18	-.11	-.26	-.25	-.13	-.27	.04	.06	-.32
1 to 2	N. Image → I. Comm.	-.24								
2 to 3	N. Image → I. Comm.	-.30	-.24	-.40	-.20	-.39	-.27	-.45	-.20	-.32
1 to 2	I. Comm. → N. Image	-.26								
2 to 3	I. Comm. → N. Image	-.19	-.20	-.18	.06	-.38	-.12	-.36	-.07	-.09

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Table Four

Cross-lagged Partial Correlation Coefficients for the Relationships between Interpersonal Communication Nixon's Image* and

Times	Hypotheses	Total Sample (N=114)	Daytime TV (N=66)	No Daytime TV (N=48)	Newscasts (N=50)	No Newscasts (N=64)	News-Papers (N=83)	No News-Papers (N=31)	Great Attention to Watergate (N=60)	Low Attention to Watergate (N=54)
		Contingent Conditions								
1 to 2	Distrust → I. Comm.	-.27								
2 to 3	Distrust → I. Comm.	-.06	.10	.03	.05	.06	.03	.29	.10	.05
1 to 2	I. Comm. → Distrust	.10								
2 to 3	I. Comm. → Distrust	-.20	-.13	-.29	-.25	-.16	-.28	-.02	.05	-.45
1 to 2	N. Image → I. Comm.	-.10								
2 to 3	N. Image → I. Comm.	-.25	-.19	-.36	-.25	-.25	-.36	-.21	-.31	-.35
1 to 2	I. Comm. → N. Image	-.03								
2 to 3	I. Comm. → N. Image	-.08	-.16	.00	-.04	.05	-.22	-.11	-.02	.07

*The value of the dependent variable at time one is assumed to be statistically controlled for by use of the partial correlation technique.

Those persons interested in comparing the relative strength of alternate hypotheses under the various conditions should refer to the sets of coefficients which are enclosed in boxes above.

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The Sixteenfold Table Approach

Lazarsfeld's sixteenfold table approach was developed to permit causal inferences to be made from two dichotomous variables measured at two points in time. The relationship between the two variables is analyzed such that causal influence can be attributed to one variable. The technique was initially applied to studies of the relationship between party membership and presidential candidate preferences in elections during the 1940's (Lipset, et al, p. 1161). Respondents in opinion studies were classified into one of four categories based on their positions on the two variables being studied:

1) Republican (+)/ for Wilkie (+)
2) Republican (+)/ against Wilkie (-)
3) Democrat (-)/ for Wilkie (+)
4) Democrat (-)/ against Wilkie (-).*

* Arithmetic signs are assigned arbitrarily to indicate the different categories of the variables.

These four categories can be regarded as an exhaustive set of states into which any respondent will fall at any point in time. The movement or transition of respondents from one state to another is studied by constructing a "turnover" table in which the classification of respondents at one point in time is cross-tabulated with their classification at a second point in time. This yields a table like Table I below.

(Table I about here)

Many of the cells in this table provide data which can be used as evidence to support or deny certain hypotheses about the relationship

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between the two variables. The cells in the diagonal running from left to right provide evidence of stability in the relationship. They indicate which respondents have not changed states from time one to time two. The cells in the opposite diagonal provide evidence which cannot be clearly interpreted. Respondents in these cells have changed categories on both of the variables being examined. In a sense, they appear to have jumped from one extreme to another. This jump cannot be accounted for by either variable. One is as likely to have "caused" the jump as the other. Thus, if the cells in this diagonal contain large numbers of respondents, the sixteenfold table approach cannot be expected to yield useful causal inferences. Several plausible interpretations can explain why the opposite diagonal may be large. One, the variables were not measured reliably and the persons in this diagonal represent "measurement error." Two, the respondents are shifting quickly between the various states and the researcher has allowed too much time to elapse between his measurements. People have moved to one state and then had time to move again. Three, the researcher has inadequately conceptualized the phenomena and the respondents are jumping from one state to its opposite as a result of exogenous variables which are not included in the model. When the opposite diagonal is found to be large, the researcher should design future research to take these interpretations into account.

The remaining eight cells in the table each provide evidence to support complementary or conflicting causal inferences (hypotheses). These eight possible hypotheses are listed below. In Table II, the cell which provides the evidence for each hypotheses has been indicated.

(Table II about here)

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Two characteristics of these hypotheses should be noted. One, if X is conceived of as a continuous rather than a discrete variable, then either hypotheses one and four should both be true, or hypotheses two and three should both be true. If either of these pairs of hypotheses is not consistently supported by the data, then X may be incorrectly conceptualized, measurement error may exist, the changes in X and Y may result from exogenous variables, or the causal interval (time it takes X or Y to cause changes in each other) may not have been correctly identified. Similarly if Y is operating as a continuous variable, then hypotheses five and eight should both be true or hypotheses six and seven should both be true. Two, if X and Y are acknowledged to be discrete variables, then either H_1 or H_4 can be supported by the data but the other need not be. Similarly, either H_2 or H_3, H_5 or H_8, H_6 or H_7 can be supported individually. However, certain restrictions still exist. H_1 and H_3 should not both be true. If they are, then both conditions of X are producing the same change in Y, and X is more parsimoniously conceived of as having a single category. Similarly, if H_2 and H_4 are supported, X is best conceived of as a single category. If H_5 and H_7 are supported, or if H_6 and H_8 are supported, Y can be collapsed into a single category.* If the researcher is reluctant to collapse the categories of either X or Y, he may account for his data in terms of measurement error, influence of exogenous variables, or an incorrectly chosen causal interval.

* In some cases, X and Y are conceptualized in such a way that collapsing of the categories is logically impossible. For example, if the two categories of X are: 1) X is present; 2) X is absent; then collapsing of X into one category yields the inference that Y changes whether X is present or absent. In this case, X can be eliminated as a potential cause for Y and the researcher can focus his attention on how Y influences X.

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A quick analysis of a turnover table can yield useful information for making causal inferences. Looking at the Lazarsfeld data reported in Table I, several conclusions can be reached. First, only three "off-diagonal" respondents are reported out of 266 possible. Thus, very few ambiguous cases exist. The model meets its first test of fit to the data. Second, strong support is found for only two hypotheses: H_1 and H_4. Eleven respondents are found in cells which provide evidence for each of these hypotheses. An unusually straightforward interpretation can be made of this data because H_1 and H_4 are complementary hypotheses. Both permit the interpretation that X is the dominant influence over Y. Being a Republican apparently results in a shift to support Willkie while being a Democrat results in a shift to non-support of Willkie.

Lazarsfeld has suggested the calculation of a summary statistic which indicates the relative size and direction of the causal relationships in such a turnover table. This statistic has the advantage of summarizing information from the table into a single statistic. Yee and Gage (1968) report the following formula for this statistic:

$$I_{A,B} = \frac{8\left(\frac{\Delta H}{NH} + \frac{\Delta V}{NV}\right)}{N}$$

This formula can be translated into the terms used in the preceding discussion. The term ΔH refers to a contrast between cells 21 and 34 versus cells 31 and 24. The term ΔV refers to a contrast between cells 12 and 43 versus cells 13 and 42. NH refers to the total number of respondents in the ΔH cells. NV refers to the total number of respondents in the ΔV cells. N is the total number of respondents in the

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table. This contrast of numbers of respondents in cells can be regarded as a comparison of the strength of the various conflicting or incongruent hypotheses. In effect, it is an attempt to pit the hypotheses against one another such that the overall effects of X on Y or Y on X can be determined. If the terms we introduced representing the set of hypotheses are substituted in Lazarsfeld's original formula, the following formula is derived:

$$I_{A,B} = \frac{8\left(\frac{(H_1+H_4)-(H_5+H_8)}{N_1+N_2+N_3+N_4}\right)\left(\frac{(H_2+H_3)-(H_6+H_7)}{N_2+N_3+N_6+N_7}\right)}{N}$$

The size and direction of this statistic are a function of the extent to which X dominates Y or Y dominates X. However, the size of the statistic is reduced considerably if X and Y influence each other in a reciprocal manner. Any of the eight hypotheses can combine to increase or reduce the statistic. The statistic reflects only strong, consistent trends in the data. In this respect, it tends to be conservative in the causal inferences which it draws from the data. The size of the statistic is also reduced when the number of respondents in the contrasted cells is small relative to the total number of respondents.

In the example reported above $I_{A,B} = .012$. The value of the statistic is quite small despite the fact that X so clearly dominates Y on the basis of the evidence for hypotheses H_1 and H_4. In part, the small size. is due to the subtraction of the evidence for the incongruent hypotheses (H_2 and H_3). Also, the amount of total change induced by X is small relative to the total amount of change possible.

Lazarsfeld's statistic does not appear to be particularly useful or sensitive if a researcher is trying to make causal inferences from a

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problematic, exploratory data set. In such a case, the statistic may conceal more than it reveals. Campbell (1963, p. 24) has pointed out that in cases where the marginals of the items are extreme and different for the two variables (i.e., most respondents fall in + or - states), the observed effects of the variables may be an artifact of regression toward the mean. It may be more useful for the researcher to examine the turnover table itself and make his interpretations directly from it. However, there are no criteria for judging whether the number of respondents in a particular cell provide a significant amount of support for a particular hypothesis. The researcher can only offer plausible arguments for his decisions, not statistical tests. This may be quite acceptable in exploratory research where the researcher is content to talk about directions and trends. However, if a researcher wants to make stronger inferences and argue for their significance, he should choose other mathematical models which permit this.

In summary, Lazarsfeld's sixteenfold table approach can provide information which permits a researcher to evaluate several causal inferences at one time and reach plausible conclusions. The approach is limited to bivariate relationships. It can handle either continuous or discrete dichotomous variables but is especially appropriate for discrete variables. The approach appears to have particular usefulness in examining a set of data for support for complementary or incongruent causal relationships. Such an examination is not useful when the researcher has plausible empirical or theoretical reasons for discounting the existence of certain causal relationships. For example, it is generally accepted that rainfall causes plant growth but that plant growth has no effect on rainfall. If a researcher were using a sixteenfold table to examine the relationship between these variables, he would find much of the data in

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a sixteenfold table uninteresting except as an indication of how much measurement error is present. On the other hand, relationships between variables in communication research are rarely as well understood, particularly during exploratory stages of research. Hypotheses cannot be eliminated as implausible. Evidence for all hypotheses should be examined. Thus, the sixteenfold table may serve as an early guide to determining "what is going on" in a set of data and provide a basis for designing later research.

Coleman's Continuous Time, Discrete Space, Stocastic Model

James Coleman (1964a) has proposed a series of mathematical models useful for drawing causal inferences from bivariate relationships observed at two or more points in time. For the purposes of this paper, we have limited our attention to one model which closely resembles that of Lazarsfeld. This permits us to contrast inferences derived from the two models. The model chosen appears to be typical of the entire series. Thus, it illustrates many of the assumptions which underlie Coleman's models.

Coleman's "process" approach has been described in detail elsewhere (most recently in Jaeckel (1972)). We will mention only some of its most important characteristics here. As in the Lazarsfeld model, the categories or values of social variables are viewed as states which individuals can take on. When two dichotomized variables are considered, it is possible for individuals to be in any one of four states at any given point in time. All of Coleman's models in this series are concerned with movements by individuals between such discrete states (spaces). Coleman has diagrammed the possible shifts which can occur

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between the four states as time passes (see Table III).

(Table III about here)

The eight shifts represented by arrows in this diagram correspond to the eight hypotheses discussed above with regard to the sixteenfold table. Some important differences should be noted in the way that these shifts are conceptualized in the two models. Coleman argues that shifts between states go on continuously -- hence the term continuous time in the model's name. This is in contrast to discrete time causal models which assume that shifts in states occur during particular (discrete) causal intervals. Jaeckel (1972, p. 241) has pointed out that the continuous time assumption is ordinarily a reasonable one for social phenomena:

> To conceptualize social processes as occurring in continuous time agrees well with our intuitive conceptions of them. We naturally think of social processes (modernization, for example) as occurring continually, that is, in the form of ongoing changes in the properties of individuals and in the relations among individuals. Whether continuous occurrences are intrinsic to social processes or not, the point to be emphasized is that to think of the constituent changes as occurring at arbitrary times is the reasonable assumption. There is no prior reason for excluding any particular time points from those at which changes occur. The alternate assumption that changes in question occur at fixed discrete points in time would seem to hold for social phenomena only under special conditions, in particular under synthetic regularizing conditions such as those of an experiment.

A second difference of the Coleman approach is that it assumes that social processes develop in time according to probabilistic laws. This is the <u>stocastic</u> assumption. Jaeckel (1972, p. 242) has contrasted this assumption with the <u>deterministic</u> assumption which underlies most powerful mathematical and statistical models used by social scientists (i.e., the regression model):

> It appears intuitively reasonable to think of the individual behaviors of which these processes consist as not strictly determined in any single case and yet, as corresponding, on the average,

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> to the social and environmental conditions under which they take place. And apart from the intuitive plausibility of the stocastic assumption, there appear to be advantages intrinsic to stocastic models which make them theoretically preferable to their deterministic counterparts. Conceiving of such processes as developing in the form of a flow of probability distributions through time enlarges the range of what the models can handle. The stocastic assumption implies that variability is itself conceptually included in the model and not just added as an extrinsic error term to an equation the primary structure of which has already been determined.

Coleman uses this assumption as his basis for explaining and predicting shifts between discrete states. A central purpose of his mathematical models is to estimate the probability that particular shifts or transitions will be made between states. The simplest basis for computing such estimates is to observe the shifts between states that occur empirically from one point in time to another. Thus, the size of the transition probability which explains or predicts movement from one state to another can be computed as a function of the number of individuals who shift states relative to the number of individuals who don't shift. Of course, this assumes that observed shifts are not just the result of errors in measurement. The mathematical models which Coleman proposes estimate transition probabilities in this way.

In using estimates of transition probabilities as a basis for explaining present states of a system or predicting future states, Coleman is making the Markov assumption. It should be noted that traditional mathematical models which make the Markov assumption are discrete-time, not continuous time models. Thus, it is somewhat misleading to refer to Coleman's model as a Markov model. Jaeckel (1972, p. 244) has explained the implications of the Markov assumption:

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> The final major assumption defining Coleman's process models is the Markov assumption, that is, the assumption that the probability of a system's being in a certain state at a given time depends only on the system's state at the previous time and the corresponding transition probability. Data concerning states of the system at any earlier time are irrelevant in the sense that they cannot alter the probability distributions for the states of the system from the given time onward. In other words, knowledge of the present state of a system and of the transition probabilities suffices to determine its future development.

Of all the assumptions discussed above, the Markov assumption has proved to be the most implausible. Wiggens (1973, p. 17) has pointed out that estimates of future states of systems of social variables have proved to be quite inaccurate even when data from four or five points in time (third or fourth order Markov models) were used as a basis for estimating transition probabilities. Apparently, for social variables, the future is difficult to predict as a simple extention of the present. Coleman (1964b) has attempted to correct for inaccuracies in his estimates of future states by devising mathematical models which take into account what he terms "response uncertainty." In attempting to make this correction, Coleman demonstrates his confidence in the Markov assumption. He attempts to account for error in estimates of future states by pointing out that individuals undoubtedly differ in their transition rates. Some individuals are more likely to shift states (movers) than others (stayers).

In this paper, we have avoided using the Coleman model as a basis for prediction but have applied it as a means of describing the causal relationships existing between two variables at two points in time. Caution will be exercised in interpreting the estimates of transition rates between states. These will not be regarded as estimates of future

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rates but will be interpreted as estimates of transitions which have actually taken place. Such a narrow interpretation is warranted also by our own lack of knowledge about the variables which we will be considering.

In making causal inferences from transition rates, Coleman (1964a, pp. 160-173) sets up four contrasts between the eight hypotheses. The evidence for these hypotheses is provided by the estimated transition rates. He labels these contrasts α, β, ϕ and θ. These contrasts compare H_1 versus H_3, H_4 versus H_2, H_5 versus H_7 and H_8 versus H_6 respectively. These four main effects which are distinguished are: 1) α = the positive state of X causes transition to the positive state of Y; 2) β = the negative state of X causes transition to the negative state of Y; 3) θ = the positive state of Y causes transition to the positive state of X; 4) ϕ = the negative state of Y causes transition to the negative state of X. It is necessary for Coleman to differentiate four main effects because X and Y are not necessarily continuous variables. If they were, α and β could be summed to determine the overall effect of X and the summation of θ and ϕ would yield the overall effect of Y. In the case of discrete variables, summation could mask important evidence for conflicting hypotheses.

In making the four contrasts, Coleman is determining the relative strength of two directly competing hypotheses. H_1 : the positive state of X causes Y to become positive is contrasted with H_3 : the negative state of X causes Y to become positive. As we pointed out earlier, if the data provides evidence for both these hypotheses, then it is useless to differentiate between the two states of X. X should be collapsed and treated as a single state. Thus, in cases where the Coleman main effects

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are small, researchers should examine the data to determine whether this is due to sizable transition rate estimates for conflicting hypotheses which cancel each other out. If so, the variable in question might be collapsed and the bivariate relationship reassessed. Of course, this can be done only in those situations where collapsing of the variable is meaningful.

One important limitation of the Coleman model is that it involves additional assumptions when the cells of the off-diagonal in the sixteenfold turnover table are large. These cells contain the respondents who have shifted more than one state during the time interval being measured. Coleman provides for an "exact solution" for transition rates which attempts to sort out the two shifts which moved individuals to these states. However, this exact solution involves making assumptions about how shifts are occurring. These assumptions are at best plausible guesses as to how shifts will occur in "typical" situations. As Coleman (1964a, p. 170) points out, the exact method increases the size of transition rate estimates. Such increases could result in overestimates of causal influence if the off-diagonal cells are large because either X or Y has been conceptualized poorly or measured inaccurately. In cases where researchers are doing exploratory research, the assumptions underlying the exact solution may be unwarranted. It would appear wiser in such situations to attempt to account for why the off-diagonal cells are so large. Usually, the most plausible explanation is that too much time has elapsed between measurements. Thus, while Coleman offers a way out of the dilemma raised by large off-diagonal cells, the solution should be regarded with some caution.

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Cross-Lagged Correlation

The last model which will be considered here is cross-lagged correlation. This model has been discussed in detail elsewhere (see Chaffee 1971, Rozelle and Campbell (1969)).

Our purpose here is to discuss how this approach resembles both the Lazarsfeld and Coleman models. A comparison of cross-lagged correlation to the Lazarsfeld model has already been made by Campbell (1963, pp. 235-242). Important differences exist between these models. Cross-lagged correlation assumes that the variables are continuous. In addition, all of the assumptions for the computation of correlation coefficients must be met. In particular, relationships between variables are assumed to be linear. Despite these differences, Campbell (p. 236) points out that "cross-lagged panel correlation would seem to be the most feasible means of extending the sixteenfold table beyond the dichotomous situation."

In the cross-lagged correlation model, the eight hypotheses discussed above are contrasted with one another to arrive at estimates of main effects. The purpose of cross-lagged correlation is to arrive at a final contrast between the total effect of X on Y and the total effect of Y on X. This contrast permits a conclusion concerning the causal priority of either the X or the Y variable. As we have seen, such a contrast can be accomplished with the Lazarsfeld or the Coleman model. However, the result can be misleading. The contrast yielded by cross-lagged correlation is no less likely to be misleading particularly when a data set fails to satisfy the assumptions of the model.

The advantage of cross-lagged correlation is that it yields coefficients

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which are interpretable using traditional, widely accepted tests of statistical significance. However, despite the relative ease of determining statistical significance, drawing causal inferences from cross-lagged correlations can be more problematic than drawing similar inferences from either the Lazarsfeld or Coleman models. In general, problems arise in interpretation when the researcher cannot be certain that his variables are in fact continuous, that his measures are reliable (or at least have the same degree of reliability over-time) or that the relationships between variables are linear. Whenever such questions about the data arise, a straightforward interpretation of the cross-lagged correlations cannot be made. For example, if the data are not continuous, H_1 might be true but H_4 might not. The cross-lagged correlations force the interpretation that if one of these hypotheses is true then the other is equally true. If measurement error fluctuates from the first measurement of variables to the second, this fluctuation may produce incorrect inferences. While the same error in interpretation could be made with the Coleman or Lazarsfeld approaches, certain clues in the data may warn of fluctuating reliability. For example, large frequencies in the off-diagonal cells of the turnover table may indicate shifting reliability.

The cross-lagged correlation model is the most powerful of the three models considered. It permits the information contained in the data to be used most efficiently in making causal inferences. It also serves to summarize the data very concisely. But this conciseness and efficiency are advantageous only when the data meet the assumptions of the model.*

* See Chaffee (1971) for a more complete explanation of assumptions for the cross-lagged model.

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. . . It is true that some of these assumptions can be violated without seriously altering results. However, few guidelines exist that can enable a researcher to determine whether or not he has violated too many assumptions or the wrong combination of assumptions. Thus, of the three models, cross-lagged correlation is least likely to be useful to a researcher who has collected exploratory data. On the other hand, if a researcher knows a great deal about his variables and their relationship to one another, cross-lagged correlation may offer the best way to efficiently make concise causal inferences. It should be kept in mind that cross-lagged correlation is a deterministic model. In analyzing data sets where the underlying social process is likely to be probabilistic, the Coleman model may yield more useful findings.

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Table I

Concurrent Change in Vote Intention
and Personal Liking for Willkie

Interview		Second Interview ++	+-	-+	--	T
First Interview	Republican (+) for Willkie (+)	129	3	1	2	
	Republican (+) against Willkie (-)	11	23	0	1	
	Democrat (-) for Willkie (+)	1	0	12	11	
	Democrat (-) against Willkie (-)	1	1	2	68	
	Total	142	27	15	82	

Table II

Causal Inference from the Sixteenfold Table

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Time One \ Time Two	++	+-	-+	--
++	No Change 11	Hypothesis Two (H_2) 12	Hypothesis Six (H_6) 13	Uncertain 14
+-	Hypothesis One (H_1) 21	No Change 22	Uncertain 23	Hypothesis Eight (H_8) 24
-+	Hypothesis Five (H_5) 31	Uncertain 32	No Change 33	Hypothesis Four (H_4) 34
--	Uncertain 41	Hypothesis Seven (H_7) 42	Hypothesis Three (H_3) 43	No Change 44

Descriptions of the Hypotheses

Cell Number	Hypothesis Number	Description
21	H_1	$+X \rightarrow Y\uparrow$ $(+- \rightarrow ++)$*
12	H_2	$+X \rightarrow Y\downarrow$ $(++ \rightarrow +-)$
43	H_3	$-X \rightarrow Y\uparrow$ $(-- \rightarrow -+)$
34	H_4	$-X \rightarrow Y\downarrow$ $(-+ \rightarrow --)$
31	H_5	$+Y \rightarrow X\uparrow$ $(-+ \rightarrow ++)$
13	H_6	$+Y \rightarrow X\downarrow$ $(++ \rightarrow -+)$
42	H_7	$-Y \rightarrow X\uparrow$ $(-- \rightarrow +-)$
24	H_8	$-Y \rightarrow X\downarrow$ $(+- \rightarrow --)$

*A verbal description of this hypothesis would be: X in the positive state causes Y to assume the positive state.

Table III

The Four States of Coleman's Model

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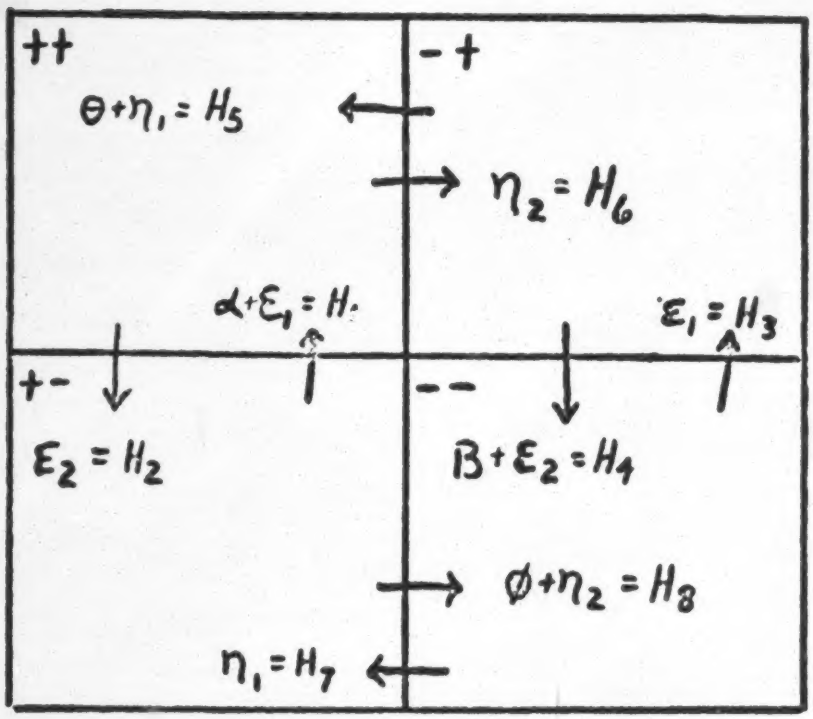

State One

State Two

State Three

State Four